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The Application of Reverse Mortgages in Aging Society

反向房屋貸款在高齡社會的應用

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Abstract

Due to the low mortality rates and decreased fertility, as well as the subsequent increased aging problems, insufficient pensions have become a worldwide serious issue. In addition to traditional resources, such as public and private pensions, commercial annuities, individual savings and investments, reverse mortgages provide a new resource option for retirement. We investigate the application of reverse mortgages to retirement and analyze the risk for both governments and financial institutions of issuing reverse mortgage products. Numerical results show that gender, age, loan rate, the return of house price, and the maximum loan amount have significant impact on the risk of issuing reverse mortgages. These factors are very sensitive to the loss distributions of reverse mortgages, therefore risk management is a crucial means for governments and financial institutions to control the risk of reverse mortgages to avoid huge losses.

Keywords: reverse mortgage; home reversion; aging society

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摘　要

人口老化及低生育率已是全世界各國共同的現象，平均壽命隨著經濟發展所帶來醫療及居住環境之改善而快速延長中，退休準備不足因此成爲一個嚴重且急迫的議題，具有高可取得性的反向房屋抵押貸款是除了國民年金、企業退休金、個人儲蓄等一般之退休來源之外的一個新的選擇。本研究探討金融機構在發行反向房屋抵押貸款商品或是政府提供反向房屋抵押貸款商品之保證保險時所承受的風險，研究結果顯示性別與年齡、貸款利率、房價報酬率、房價標準差和可貸款額度對反向房屋抵押貸款之保險人或發行機構之風險都有顯著的影響。因此，金融機構在發行反向房屋抵押貸款商品或是政府提供反向房屋抵押貸款商品之保證保險時，若缺乏適當的風險控管，可能會產生高額的損失。

關鍵字：反向房屋抵押貸款、房屋轉換計畫、高齡社會

1. Introduction

Mortality improvement has gained great research attention recently. Taiwan, like other developed countries, is facing a serious aging problem. In the past decade, the structure of Taiwan's population has aged significantly and simultaneously experienced low fertility rates. Improvements in material conditions and rising medical care standards have lengthened people's lifespan and decreased birthrates. According to statistics compiled by the Ministry of the Interior, there were 1,480,000 elderly people in September 1993, representing 7% of Taiwan's total population, which meets the criteria for an old age society set by the United Nations. In 2002, the number of elderly topped 2,000,000, and then soared to 2,130,000 at the end of October 2004, accounting for 9.43% of the total population. Elderly people will make up 10% of the population by 2011 and more than 20% by 2031, outnumbering the youth (those under 15 years of age).

Between 1951 and 1971, the old age dependency ratio remained around 5%; that is, every 20 working people supported 1 elderly citizen in Taiwan. However, the number of supporters dropped from 20 to 9 in 1995, and by October 2004, the old age dependency ratio had increased to 13.25%. During the past 20 years, the burden on the working population increased 5%, and according to the Taiwanese government's estimation, every three persons of working age will support one elderly citizen by 2036. This increase in old age dependency makes it harder for the wage-earning population to support the elderly. When seniors cannot rely on their children to support their consumption, the issue becomes whether seniors can live by themselves on the wealth they accumulated before retirement.

In addition to common resources, such as public pensions, private pensions, commercial annuities, individual savings, and investments, a new resource for retirement has emerged in the form of reverse mortgages. Many seniors find these mortgages easier than standard home equity loans, because they fail to qualify for standard loans due to their low income levels. A reverse mortgage never asks the homeowner to pay accrued interest and only comes due when he or she moves out of the house or dies. The various reverse mortgage products have similar structural features. When a homeowner meets the appropriate criteria, the financial institution offers a loan that can be taken as lump sum, as an income stream, or as a line of credit,

with various degrees of flexibility permitted between methods of borrowing. The income stream can be taken either for a fixed term or as an annuity. There are various costs involved in taking out the loans, which can be financed in part from loan proceeds. The amount of money that can be borrowed depends on the age of the borrower, the value of house, and some interest rates variables.

The most widely used reverse mortgage currently in the U.S. market is the Home Equity Conversion Mortgage (HECM), which emerged from the National Housing Act of 1987. In the HECM in the United States, an insurer charges borrowers a premium and carries the obligation of the providers when the house value drops below the loan balance or default occurs. Borrowers mortgage their houses but keep ownership. As a result of the no negative equity guarantee, consumers or their heirs do not have to repay the difference if the debt exceeds the value of the house. However, consumers or their heirs can gain the difference if the house value exceeds the debt. The insurer will suffer a loss if loan balance exceeds the house value at the time the contract is terminated. In other words, there is no loss for insurers during the contract period, even if the house value exceeds the debt.

Venti and Wise (2001) find that most seniors tend not to sell their homes or move to smaller ones to support general consumption needs. Therefore, home ownership rates continue to remain high among the elderly, and home equity does not appear to fall with age. Therefore, reverse mortgages may become one of the primary financing resources for the elderly in the future in Taiwan. Several studies have investigated the risk and structure of reverse mortgages, including Boehm and Ehrhardt (1994), Szymanoski (1994), and Rodda, Lam and Youn (2004), but few discuss the risk management of reverse mortgage according to actuarial points. We therefore intend to investigate the application of reverse mortgages to retirement and analyze the risk to both governments and financial institutions of issuing reverse mortgages. Specifically, we calculate the net single premium of reverse mortgages and analyze loss distributions using Monte Carlo simulations. Results of his study may assist governments and financial institutions in understanding the risks associated with issuing reverse mortgages, which in turn enables them to issue reverse mortgages with effective risk managements. In addition, insurers can better solve the economic problem of an aged society by applying reverse mortgages appropriately.

2. Reverse Mortgage Products and Retirement

2.1 Reverse mortgages and long-term care expenses

Long-term care expenses make up a large proportion of the financial demands on the elderly. According to Cheng and Shen (1995), average long-term care expenses are about $30,000 per month in Taiwan. Because the annual average savings of a household is $190,000, long-term care expenses represent a heavy financial burden for most people. Elderly people with chronic health conditions might be forced to sell their homes to pay for their long-term care, and consequently could face serious problems.

As an alternative to selling their homes, impaired homeowners may be interested in using a reverse mortgage to liquidate their housing wealth without having to move or relinquish control over this asset. To address the potentially huge costs of long-term care, they also need additional resources. One important option is long-term care insurance, which represents an essential financial tool for protecting the retirement assets of seniors. According to Wu et al. (2001), the average cost of taking care of a disabled family member at home is $12,196 per month in Taiwan. Employing a foreign caregiver demands $20,000 per month, and employing a native caregiver requires $45,000. The cost of moving into nursing home is $33,558.

To cope with the heavy burden of caring the elderly, we use a reverse mortgage with government insurance as an example. Suppose that the initial house price is $1,000,000, and the owners can get $400,000 to buy a whole life annuity. The money amount required for the different payment types are shown in Table 1.

Table 1 Annual payment for different types of reverse mortgages

Payment type	Annual payment
Annuity	$40,816
20-year fixed-term payment	26,103
10-year fixed-term payment	45,526
5-year fixed-term payment	84,798

Stucki (2006) proposes two strategies to fund the cost of long-term care using reverse mortgages and long-term care insurance. One strategy applies the proceeds of a

reverse mortgage to pay for insurance premiums, whereas the other limits the amount of insurance purchased by elders by increasing the amount of long-term care self-funded through a reverse mortgage. According to Stucki's (2006) strategy, we use the long-term care insurance of company A as an example. Its premium payment period is 20 years, so we design the reverse mortgage with a 20-year fixed-term payment.

In Stucki's (2006) first strategy, reverse mortgage borrowers have sufficient funds to purchase a meaningful amount of long-term care coverage. A 65-year-old man would need to pay $268,800 for 20 years to buy the insurance coverage that will offer him $30,000 monthly when he requires a caregiver's service part-time or $45,000–60,000 when he needs full-time care. If he uses the reverse mortgage as an available source of funds for his long-term care insurance, his house must be worth more than $13,000,000 to be sufficient. A woman in the same condition, but with different premiums and mortality expectations, must own a house worth more than $88,500,000.

According to Stucki's (2006) second strategy, a 65-year-old man could pay $89,600 to purchase a insufficient amount of long-term care coverage, which will offer him $10,000 per month when he needs part-time care and $15,000–20,000 when he needs a full-time caregiver. The premium for this coverage for women is $77,000. Therefore, men and women need a house worth more than $3,400,000 and $3,000,000, respectively, and can save the rest of the value of the house for their future use.

These two strategies are both available for different retirement purposes and apply reverse mortgages. However, the second strategy is more flexible and designed for younger people to prepare for their retirement by buying long-term care insurance as basic coverage, and then using the reverse mortgage as a complement if needed. Thus, younger people should buy long-term care insurance to take advantage of the lower premiums and reduce their risk of experiencing poverty during their retirement.

2.2 Types of reverse mortgage products

We illustrate different reverse mortgage products in three countries—the United States, United Kingdom, and Australia—and compare them in Table 2.

2.2.1 United States.

Federal-insured HECM loans are available to most homeowners of age older than 62 years who own their primary residence free and clear from mortgages, or who can pay off their mortgage easily. During the 1990s, the demand for reverse mortgages was

extremely small; less than 1% of eligible homeowners. In recent years, however, the market has expanded, with the number of reverse mortgages rising from 6,640 in 2000 to 43,131 in 2005—a growth rate of 5.49 times in five years.

There are four main types of HECM in the United States with different payment plans:

1. Term loans schedule loan payments for a specific number of months, not exceeding the principal limit at the time of the payment.
2. A line of credit, offering unscheduled advances up to the available principal limit at the time of the request from the borrower.
3. Tenure payments, made as an annuity, continuing as long as the borrower lives in the house.
4. A combination option, integrating the term and line-of-credit approaches.

Most borrowers (68%) choose the line-of-credit plan; another 20% choose a combination term/line-of-credit option.

The federal insurance of these mortgages represents an important feature in this market. The Federal Housing Administration (FHA) runs an insurance program for reverse mortgages, called the Home Equity Conversion Mortgage Program, with which it insures that the lenders will make the agreed-upon payments. When the outstanding balance reaches 98% of the maximum claim amount, the lender automatically assigns subsequent payments to the FHA. Thus, the financial guarantee of FHA makes commercial financial institutions more confident about issuing reverse mortgages without worrying about huge unexpected losses.

Regulation in the United States will not be complete without covering other types of equity release products or reverse mortgages not insured by the U.S. government. In addition, federal truth-in-lending laws require providers to disclose a ‘Total Annual Loan Cost,” which combines all costs of reverse mortgages into a single annual average rate. Banking regulators oversee bank provider disclosure of information under the truth-in-lending legislation, whereas the Federal Trade Commission (FTC) monitors nonbank providers’ compliance.

2.2.2 United Kingdom.

There are three main kinds of the reverse mortgages, called lifetime mortgages, in the United Kingdom:

1. A roll-up mortgage --- borrowers receive a lump sum or regular income and are

charged a monthly or yearly interest that is added to the loan. The amount they originally borrowed, including the rolled-up interest, is repaid as their home eventually is sold.

2. A fixed repayment lifetime mortgage --- borrowers receive a lump sum income but do not have to pay any interest. Instead, when the home is sold, they pay the lender a higher amount (agreed in advance) than they borrowed. The lender uses this higher sum to repay the mortgage as the home is sold.
3. An interest-only mortgage --- borrowers receive a lump sum income and pay a monthly interest on the loan, which can be fixed or variable. The amount they originally borrowed is repaid when the home eventually is sold.

2.2.3 Australia.

Reverse mortgage products generally are available only to consumers aged 55 years and older who own their own homes or only have a small number of mortgage balance outstanding. The amount available for borrowing usually is restricted to 20–40% of the total property value. Most products offer the capacity to borrow additional amounts as the consumer ages, and all of them permit consumers to make voluntary repayments over the term of the loan. Some products can also be transferred to other properties, at the providers' discretion and depending on the value of the new property.

Some reverse mortgage providers in Australia have established an industry association, the Senior Australians Equity Release Association of Providers (SEQUAL), whose Code of Conduct compels its members to join the ASIC-approved External Dispute Resolution (EDR) scheme. SEQUAL's Code of Conduct further requires all SEQUAL members to:

1. Ensure that all products include a clear and transparent no negative equity guarantee.
2. Clearly and accurately identify to consumers all the costs associated with the transaction.
3. Ensure full and clear disclosure of the costs of the product, including a tool illustrating the potential effect of future house values, interest rates, and the capitalization of interest on the loan.
4. Ensure that all consumers obtain independent legal advice.
5. Ensure that all loans are written under the UCCC, irrespective of the use of the proceeds from the loan.

Table 2 briefly illustrates the comparisons of reverse mortgages in these three countries.

Table 2 Comparisons of reverse mortgages

Characteristic	U.S.A. HECM	Britain	Australia
Expense loading	Yes	Yes	No
Options of the assets protection	No	No	Yes
Mainstream of loan interest rate	Variable interest rate	Constant interest rate	Variable interest rate
Application qualification	Over 62	No especially stipulated	Over 50
Withdraw expense of refund ahead	No	yes	no, yes, for constant interest rate
Government' insurance	yes	No	No
Fix annuity payments	No	yes	No
Portable option	No	yes	yes
Independent specialized advisor	Essential		
No negative equity guarantee	yes		
Termination conditions	Consumer's death, moving out, violating the contract		

2.3 Home reversion

The main difference between reverse mortgages and home reversion is that the ownership of the house belongs to the financial institution in a home reversion plan. That is, the reversion company purchases part or all of the consumer's home at a price usually 35–60% of the full market price. In return for this discounted purchase price, the consumer retains the right to live in the house for life or until voluntarily moving on to alternative accommodations, such as a nursing home. The level of the discount depends on the age and life expectancy of the consumer and the risk borne by the provider, namely, that it must wait a considerable period before it can realize any profit. Some lenders only provide the capital released in the form of extra income, or an annuity, whereas others offer the choice of receiving a lump sum or receiving both. However, with a home reversion scheme, the consumer may miss out on any increase in the value of the property sold, in which case they would have to pay the top market price to buy back their property.

3. The Risk of Reverse Mortgages

3.1 Financial institutions' risks

Most reverse mortgages do not provide negative equity guarantee. Due to the long contract period, the provider may suffer losses if the house value declines lower than the loan balance when the contract is terminated. Attributing factors include the value of the house, the interest rate, and the terminate rate.

First, unlike in general home mortgages, the loan balance of reverse mortgages increases over time. If the home's value does not increase according to the providers' expectation, the providers suffer the losses. However, they can diversify part of the risk associated with house value fluctuation by maintaining collaterals in different districts. Because the value of a house is not a stable time series, the difference between actuality and expectation will increase over time.

Gau (1987) indicates that no one can forecast house prices in the long run. In practice, U.S., U.K., and Australia providers all limit the maximum loan amount strictly to manage the risk of house value volatility.

Some related value problems pertains to the moral hazard of home maintenance. First, those who apply for reverse mortgages generally are quite old and poor, so it is unreasonable to ask them to repair or even remodel their homes. Instead, many providers limit the maximum loan amount according to a lower rate of return.

Second, most products use a variable interest rate to discount and accumulate the loan balance, though providers suffer increased risk if the interest rate rises. That is, a higher interest rate decreases the probability as the house value is lower than the loan balance. Because the risk cannot be diversified, providers receive the risk premium in their loan interest rate.

Third, people all over the world are living longer than before, which creates a potential risk for reverse mortgage providers. Creating a reasonable mortality model is the way to resolve the problem. However, if most applicants are sick, using the recently improved mortality rate is unfair. Furthermore, the problem of adverse selection has not been proved in the market yet; for example, Davidoff and Welke (2005) suggest that no significant averse selection exists in the U.S. market.

3.2 Consumers' risks

The key message for consumers is that they must fully understand the product and their obligations. We integrate suggestions for consumers from the FSA (FSA Factsheet 2007), ASIC, and FHA, which all urge consumers to obtain independent legal and financial advice before entering into equity release arrangements. Furthermore, consumers must also consider the following issues:

1. Is the loading of the contract very clear?
2. Who is obliged to maintain the property?
3. Does the contract include no negative equity guarantees, which guarantee that the provider will bear any difference if the debt exceeds the value of the property?
4. How will the consumer pay for medical or long-term care expenses in the future if he or she uses up the maximum loan amount limit now?
5. Is a fixed or a variable interest rate better?
6. Who owns the house after signing the contract? Is there any condition that may result in the consumer losing ownership?
7. What is the prepayment term? Are there any cancellation penalties?
8. What conditions will terminate the contract?
9. Is the provider financially sound and/or prudentially regulated?
10. How will the contract affect the consumers' pension and tax?

4. Risk Management for Reverse Mortgages

4.1 Models

The most important factors involved in reverse mortgages are the interest rate, house value, and termination rate. DiVenti and Herzog (1990) assume a fixed interest rate and model the growth rate of the house value and mortality with a two-stage stochastic simulation model. Boehm and Ehrhardt (1994) instead assume no house price volatility risk and thus model the interest rate, on the basis of the stochastic process recommended by Cox, Ingersoll, and Ross (CIR) (1985), to calculate the price of derivatives that can hedge the interest rate risk of reverse mortgages. They find that the interest rate risk of reverse mortgages is higher than those of the other two fixed income securities. Using a fixed interest rate and the premium FHA rules, Szymanoski

(1994) simulates house value with a geometric Brownie motion, and then finds the limit of the loan using an actuarial method.

No consistent conclusion exists regarding the relationship between house prices and interest rates. Tsatsaronis and Zhu (2004) suggest that higher interest rates have a negative impact on house prices, whereas Berg, Gu and Lien (2007) suggest when interest rates are rising faster than gross domestic product (GDP) growth, or declining faster than GDP's declining, a negative correlation should emerge between house prices and interest rates. When interest rates are rising slower than GDP growth, or declining more slowly than GDP's declining, they anticipate a positive correlation between house prices and interest rates.

Allen and colleagues (2006) verify the long-run relationship between house prices in Canada from 1981 to 2005, as well as the idiosyncratic relations between city prices and city-specific variables. Their results suggest that city house prices correlate only weakly in the long run. Both the U.S. data used by Arslan and Guler (2006) and the Asian area data used by Zhu (2006) suggest that the correlation between house prices and interest rates is unstable in the long run.

We ignore expense loading and assume that interest rates and house values are independent. We further assume the house prices follow a geometric Brownie motion as follows:

$$\frac{dH}{H} = \mu dt + \sigma dz$$

With this random walk, the annual appreciation rate of each house becomes an independent observation of a normally distributed random variable with mean μ and standard deviation σ. The house value at some future time t can be expressed by

$$H_t = H_0 \times \exp\left[\left(\mu - \frac{\sigma^2}{2}\right) \times t + \sigma\sqrt{t}Z\right]$$

where H_0 is the initial house value.

It then follows that the cumulative appreciation rates are also normally distributed, but with growing mean μt and standard deviation $\sigma\sqrt{t}$. Thus, as t increases, so does the standard deviation of the cumulative appreciation rate.

We assume the loan rate is a risk-free rate, plus a risk premium. The risk premium depends on the form of the product. The instantaneous, risk-free interest rate follows the CIR (1985) stochastic process:

$$dr = q(m-r)dt + v\sqrt{r}dz$$

where r is the instantaneous spot interest rate, q is the speed of adjustment, m is the long-term rate to which r converges, $v\sqrt{r}$ is the instantaneous standard deviation, and dz is a Gauss-Weiner variable.

We further assume that mortality follows the Taiwan 2002 TSO and ignore the rate of moving out. Thus, the termination rate follows Taiwan 2002 TSO, and the terminal age is 110.

4.2Numerical results

4.2.1. Reverse mortgages with government guarantee insurance.

In this section we address three types of payments: lump sum, annuity, and fixed term. The fixed term consists of 20-year, 10–year, and 5-year terms. For our illustration of the lump sum payment, we assume a 70-year-old male consumer, who owns a home with a market value of $1,000,000. The maximum loan account is $400,000, the loan rate is risk-free rate plus 2%, and the discount rate is 3%. According to $10,000 simulations, the loss rate is 4.06%, the maximum claim is $649,674, the minimum claim is $604, the conditional tail expectation (95.94), or CTE (95.94), is 148,873, and the fair premium is $6,044.

Thus, the loss rate is low, given that the maximum loan amount is 40% of the house value. If we take the expected value of the cost to equal the premium, it represents 0.6% of the house value. However, if there is a critical change in either the house price or the interest rate, the government insurer could face huge losses. Thus, the government should adopt a tail expectation to avoid this kind of incident. For example, the CTE (95.94) is 14.8% of house value, so the available premium should fall somewhere between 0.6% and 14.8%.

With annuity payments, borrowers spend the entire loan amount with the insurers to buy a whole life annuity. The insurers do not stop paying the annuity until they decease. Because the lender is also an insurer, the risk of reverse mortgages and the risk

of an annuity are managed separately. According to the same assumptions we use for the lump sum case, the discount rate is 3% for annuity payments, and the payment is $40,816 annually. Therefore, the loss distribution of the annuity payment is similar to that of the lump sum payment.

For a fixed-term payment, providers calculate the annual payment during n future years on the basis of the maximum loan amount and 3% discount rate. The payment terminates when the payment year is over, but borrowers do not have to move out or repay the debt until the contract is terminated. If borrowers die during the payment year, providers pay their heirs the remaining payment, discounted at 3%, at the time of borrower's death.

Table 3 shows the fixed-term payments of reverse mortgages with government insurance: the shorter the duration of the annuity payment, the larger is the loss rate. Therefore, if the duration payment is shorter, borrowers receive larger payments each time. The loan balance accumulates faster, and the loss rate therefore is larger.

Table 3 Reverse mortgages with government insurance: Fixed-term payments

n	Loss rate	Maximum claim	Minimum claim	CTE(1-loss rate)	Premium
20	2.25%	470,621	309	115,178	2,592
10	3.07%	553,588	161	140,918	4,326
5	3.78%	622,134	491	144,542	5,464

The numbers are based on model forecasts and calculated with $q = 0.2137$, $m = 0.0407$, $\nu = 0.0276$ in the CIR (1985) interest rate model; $\mu = 0.04$, $\sigma = 0.1$ in the geometric brownie motion house price model; the Taiwan 2002 TSO experience mortality rate.

4.2.2 Reverse mortgages without government guarantee insurance.

In Australia and the United Kingdom, borrowers mortgage their houses but maintain ownership. Because of the no negative equity guarantee, providers bear the difference if the debt exceeds the value of the house, but consumers or their heirs can obtain the difference if the house value exceeds the debt.

Without government insurance, financial institutions must take risk fully upon themselves. We again consider the three types of payments associated with reverse mortgages: lump sum, annuity, and fixed-term (20, 10 and 5 year).

Using the same assumptions as we did previously for the lump sum payment scenario, from 10,000 simulations, we obtain a loss rate of 0.7%, a maximum claim of $667,116, a minimum claim of $2,132, and a cost of CTE(99.3) at 17.6% of house value. If the capital cost is 3%, the financial institution will have a positive present value of 68,763; whereas if the capital cost is 5%, the financial institution gains a negative present value of $-2,911.With an annuity payment, borrowers again spend the entire loan to acquire a whole life annuity, and insurers pay them the annuity until they die. We again assume consumers are 70-year-old men, the market value of the house is $1,000,000, the maximum loan account is $250,000, the loan rate is the risk-free rate plus 2%, and the discount rate is 3%. Borrowers can receive an annual payment of $25,510 if the loan amount is $250,000. The loss distribution of the annuity payment is the same as the loss distribution of the lump sum payment.

Finally, for the fixed-term case, similar to our analysis with government guarantees, the shorter the duration of the annuity payment, the larger is the loss rate for the financial institution. As shown in Table 4, the financial institution enjoys a positive present value for five and ten annual payments if the capital cost is 5% and the premium is the expectation of the cost. Thus, financial institutions might use tail expectations to calculate premiums rather than using cost expectations to avoid unexpected losses. In addition, though the loan balance accumulates more slowly when the fixed-term is longer, it decreases in profit since providers earn less loan interests.

Table 4 Reverse mortgages without insurance: Fixed-term payments

n	Loss rate	Maximum claim	Minimum claim	CTE(1-loss rate)	NPV1	NPV2
20	0.3%	187,053	7,772	63,208	-55,407	-106,673
10	0.55%	238,907	315	69,784	10,399	-54,219
5	0.65%	263,773	307	79,529	46,219	-23,714

The numbers are based on model forecasts and calculated with $q = 0.2137$, $m = 0.0407$, $\nu = 0.0276$ in the CIR(1985) interest rate model; $\mu = 0.04$, $\sigma = 0.1$ in the geometric brownie motion house price model; the Taiwan 2002 TSO experience mortality rate.

4.3 Home reversion

In the United Kingdom home reversion market, consumers sell their houses to get

cash at discounted prices. Unlike reverse mortgages, consumers no longer have ownership of the house. Providers, which also are the buyers, bear the difference regardless of whether the house value exceeds the sales price. With the same assumptions for the lump sum case, we further assume that consumers sell 100% ownership to providers. On the basis of their age and the assumption of the return, providers pay them a discounted price of 60% of the house price. The loss distributions of providers are plotted in Figures 1 and 2.

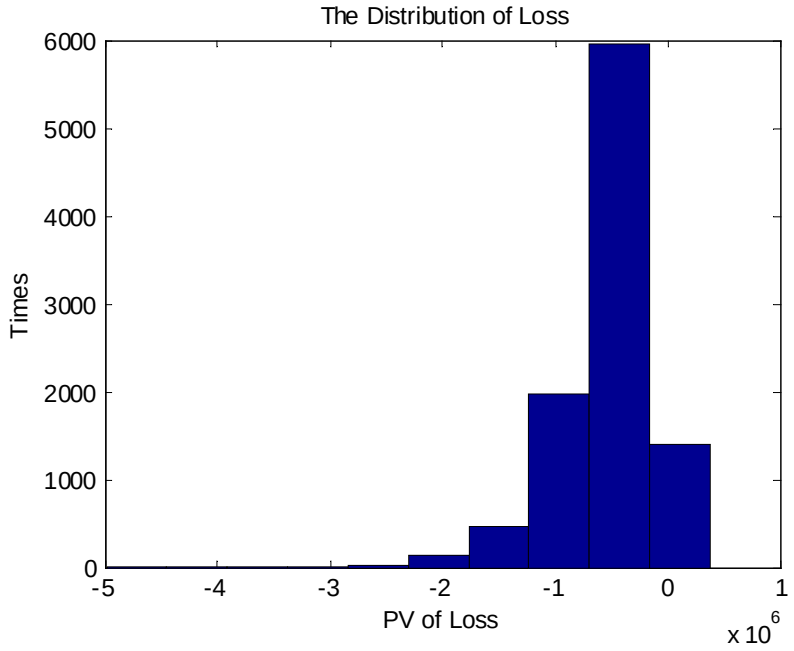

Figure 1 Home reversion: Loss distribution of the providers given 3% capital cost

In turn, the loss rate is 4.56%, the maximum claim is 375,246, and the maximum gain is 4,982,298. When the capital cost is 3%, the net present value is 538,465; when it is 5%, the net present value decreases to 296,055. Thus, the net present value of home reversion is greater than that of reverse mortgage, because providers of home reversion plans can gain from an increase in the house price. However, as Figures 1 and 2 show, a home reversion plan suffers a larger tail of negative present values, so financial institutions need to consider the fat-tailed loss distribution to avoid unexpected losses.

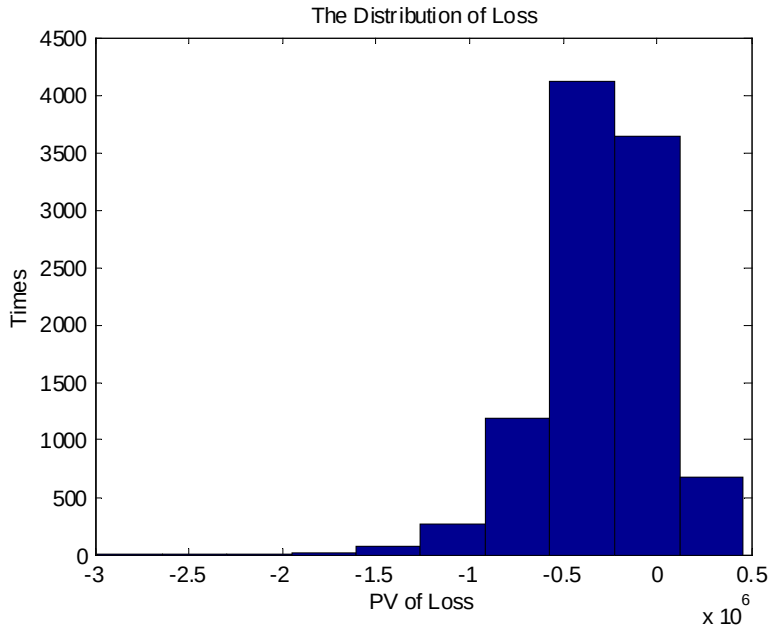

Figure 2 Home reversion: Loss distribution of the providers given 5% capital cost

For our consideration of the annuity payment type of home reversion, we note that in this case, providers pay consumers an annual payment before the contract is terminated, supposing that the consumers have sold 100% ownership to the providers. Providers calculate the annuity amount on the basis of the home price, discounted at 60%. Thus, the loss rate is 17.32%, the maximum claim is $464,385, and the maximum gain is $2,984,821. The net present values at 3% and 5% capital costs are $515,837 and $276,775, respectively.

That is, the loss rate of the annuity payment is much greater than that of the lump sum payment. Most losses in the annuity payment occur later. The present value of those losses is not great.

4.4 Sensitivity analysis

Finally, it is important to investigate how the loss distribution changes due to changes in age, gender, loan rate, maximum loan amount, and house return, as well as the associated volatility. In this section, we conduct a sensitivity analysis and set the benchmark assumptions as follows: Consumers are 70-year-old men, the market value of the house value is $1,000,000, the expected house return is 4% annually, the standard deviation is 0.1, the loan rate is the risk-free rate plus 2%, and the discount rate is 3%.

As Table 5 shows, younger consumers means a higher loss rate. We find that age is very sensitive to the loss rate. If the insured's age changes from 80 to 60, the loss rate increases 10–15 times. Women's loss rate is larger than men's because of lower female mortality rates. Thus, if governments or financial institutions charge the same premium for all consumers, it is neither appropriate for the insurers nor fair to the insured. Conditional tail expectation plays an important role in risk management in the case of fat-tailed loss distribution. We therefore can use this technique to measure any unexpected huge risk.

Table 5 Sensitivity analysis of loss distribution for gender and age

Age/Gender	Loss rate	CTE(95)	Mean	Comparison of premium	Comparison of CTE(95)
60/male	10.98%	355,376	22,567	373%	294%
70/male	4.06%	120,885	6,044	100%	100%
80/male	0.76%	12,787	639	11%	11%
60/female	17.31%	511,858	43,338	717%	423%
70/female	6.68%	209,985	10,957	181%	174%
80/female	1.76%	37,978	1,899	31%	31%

The numbers are based on model forecasts and calculated with $q = 0.2137$, $m = 0.0407$, $\nu = 0.0276$ in the CIR(1985) interest rate model; $\mu = 0.04$, $\sigma = 0.1$ in the geometric brownie motion house price model; the Taiwan 2002 TSO experience mortality rate.

Table 6 further shows that the higher the loan rate is, the higher the loss rate. If the loan rate increases from a risk-free rate plus 1% to 4%, the government's expected guarantee cost also increases from \$2,399 to 30,736—approximately 14 times higher. For providers of reverse mortgages without government insurance, higher loan rates can make up for the excess loss.

Table 6 Sensitivity analysis for loan rate

Loan rate	Loss rate	CTE(95)	Mean	Comparison of premium
+1%	2.15%	46,779	2,339	39%
+2%	4.06%	120,885	6,044	100%
+3%	7.27%	267,248	14,332	237%
+4%	12.06%	468,138	30,736	509%

T The numbers are based on model forecasts and calculated with $q = 0.2137$, $m = 0.0407$, $\nu = 0.0276$ in the CIR(1985) interest rate model; $\mu = 0.04$, $\sigma = 0.1$ in the geometric brownie motion house price model; the Taiwan 2002 TSO experience mortality rate.

According to Table 7, the standard deviation of house values has great influence on insurers' risk. If the standard deviation increases from 5% to 15%, the loss rate increases from 0.4% to 10.91%, and the expected cost jumps from $338 to 20,910. Therefore, the estimation of house prices is very important for pricing and risk management of reverse mortgages.

Table 7 Sensitivity analysis for house return and standard deviation

House return / Standard deviation	Loss rate	CTE(95)	Mean	Comparison of premium
4%/0.1	4.06%	120,885	6,044	100%
4%/0.05	0.40%	6,753	338	6%
4%/0.15	10.91%	324,504	20,910	346%
3%/0.1	7.75%	227,872	12,505	207%
5%/0.1	2.02%	52,844	2,642	44%

The numbers are based on model forecasts and calculated with $q = 0.2137$, $m = 0.0407$, $\nu = 0.0276$ in the CIR(1985) interest rate model; $\mu = 0.04$, $\sigma = 0.1$ in the geometric brownie motion house price model; the Taiwan 2002 TSO experience mortality rate.

Finally, the results in Table 8 demonstrate that the higher maximum the loan amount is, the more expensive the premium.

Table 8 Sensitivity analysis for maximum loan amount

Maximum loan amount	Loss rate	CTE(95)	Mean	Comparison of premium
30%	1.41%	30,233	1,512	25%
40%	4.06%	120,885	6,044	100%
50%	8.90%	286,657	16,456	272%

The numbers are based on model forecasts and calculated with $q = 0.2137$, $m = 0.0407$, $\nu = 0.0276$ in the CIR(1985) interest rate model; $\mu = 0.04$, $\sigma = 0.1$ in the geometric brownie motion house price model; the Taiwan 2002 TSO experience mortality rate.

5. Conclusions and discussion

Reverse mortgages and home reversions provide good tools for elderly consumers to fund their medical or long-term care expenses and solve their financial problems if they suffer serious illnesses or need long-term care. Seniors could increase the affordability of private insurance by using reverse mortgage loans to increase the amount of long-term care without funding out of their pockets. However, reverse mortgages generally are not enough to provide a main source of pensions; instead, they are more suitable to play the role for solving the financial problems associated with long-term care.

We investigate the application of reverse mortgages to retirement concerns and analyze the risk of issuing reverse mortgage products, for both governments and financial institutions. The sensitivity analyses show that gender, age, loan rate, return on house price, and maximum loan amount have great influences on the risk of issuing reverse mortgages. In particular, age is very sensitive to the loss rate, such that if the consumer's age changes from 80 to 60, the loss rate increases 10–15 times, and the expected cost increases 25–35 times. Women's loss rate is greater than men's, because of their lower mortality rate. Thus, governments or financial institutions that charge the same premium for all insured consumers are acting unfairly and perhaps underestimating risks. Moreover, higher loan rates increase the government's expected guarantee costs by approximately 14 times. If the standard deviation increases from 5% to 15%, the loss rate increases from 0.4% to 10.91% and the expected cost moves from $338 to $20,910. These numerical results demonstrate that many factors are sensitive to the loss distributions of reverse mortgages. Both governments and financial institutions must engage in risk management to reduce the risks of reverse mortgages emerging from their fat-tailed loss distributions.

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